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Goodman, Jr.

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[54] **FEED MECHANISM FOR A GEODESIC LENS**

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[73] Assignee: **Georgia Tech Research Institute**, Atlanta, Ga.

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[51] **Int. Cl.**[3] **H01Q 19/06**; H01Q 3/18

[52] **U.S. Cl.** **343/754**; 343/761

[58] **Field of Search** .... 343/754, 761, 779, 839, 343/911 L

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,343,171 9/1967 Goodman 343/754

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Attorney, Agent, or Firm—Newton, Hopkins & Ormsby

[57] **ABSTRACT**

A feed system for a geodesic Luneberg lens antenna system is disclosed, in which sequential cyclical scanning of a plurality of feed sectors of the lens from one transmitter/receiver is achieved with a minimum of dead time between successive scans.

18 Claims, 3 Drawing Figures

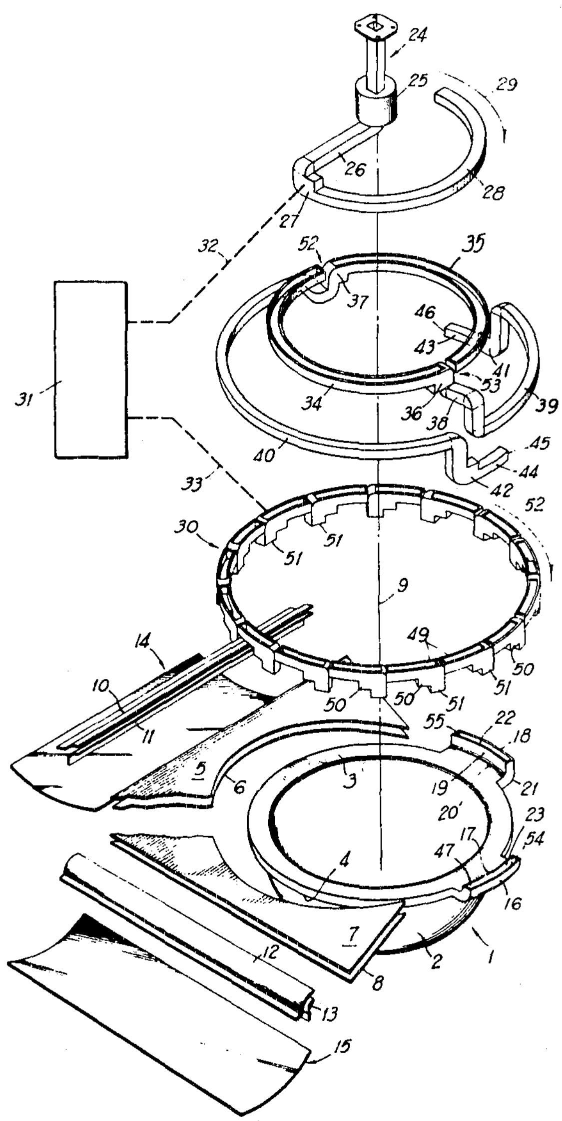

FIG 1

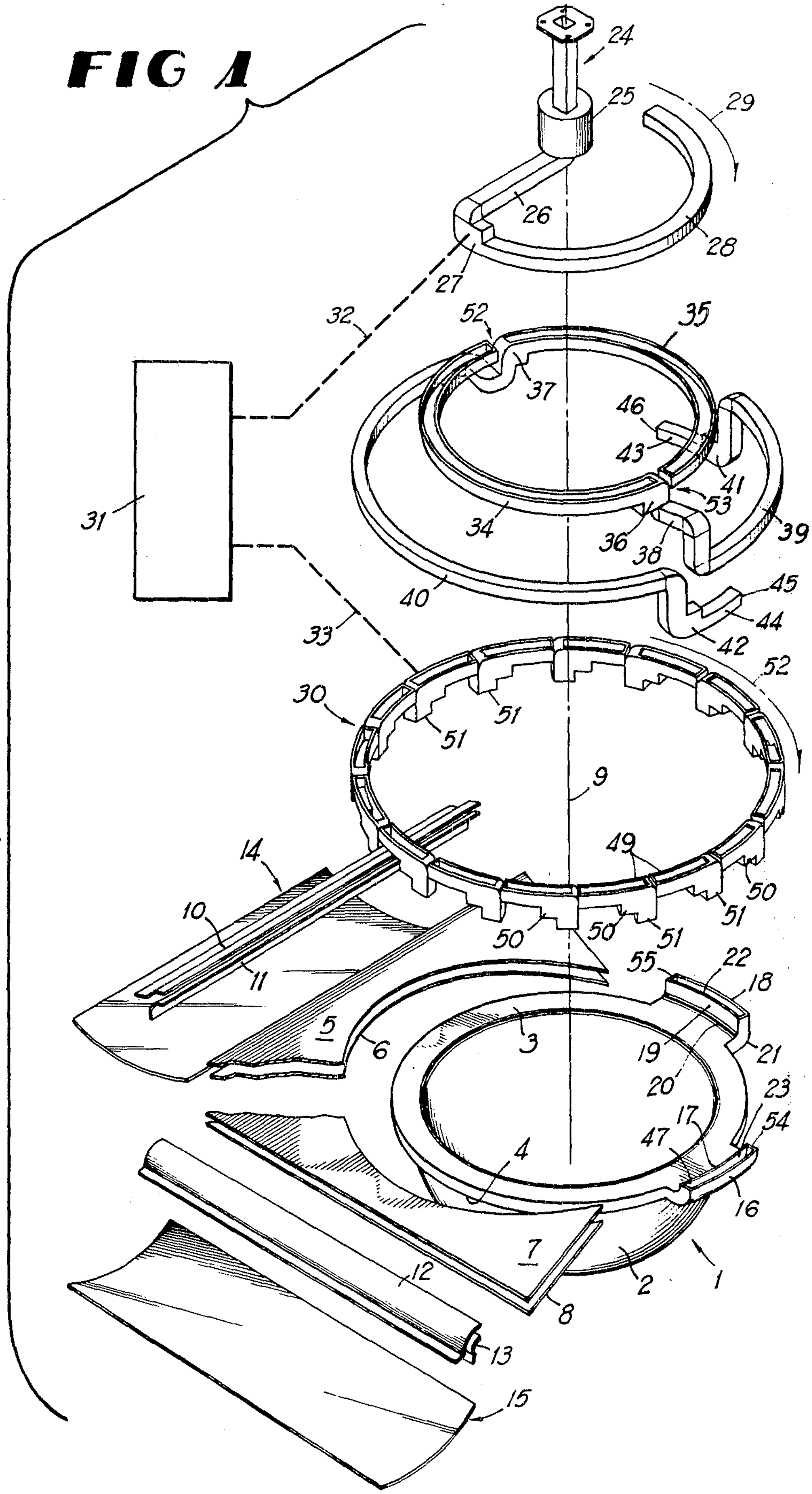
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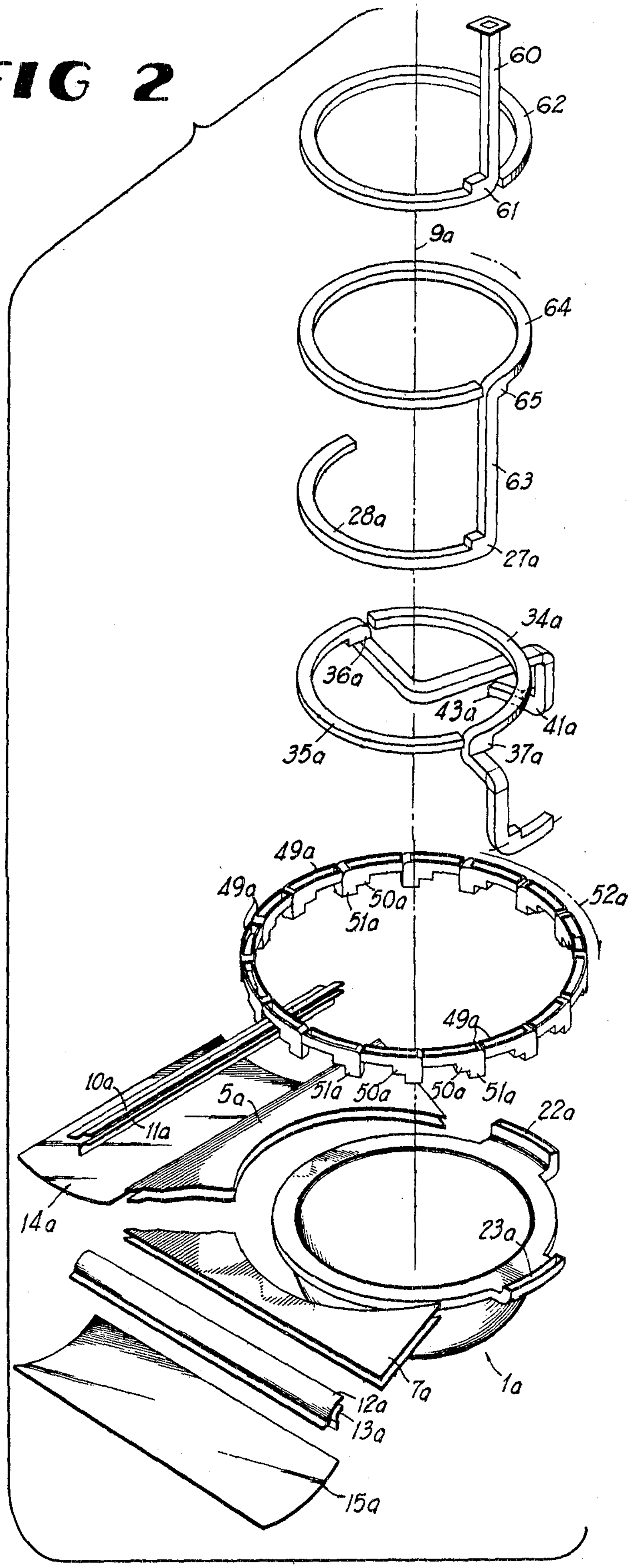
FIG 2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62
61
9a
64
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27a
34a
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43a
41a
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37a
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50a
51a
52a
49a
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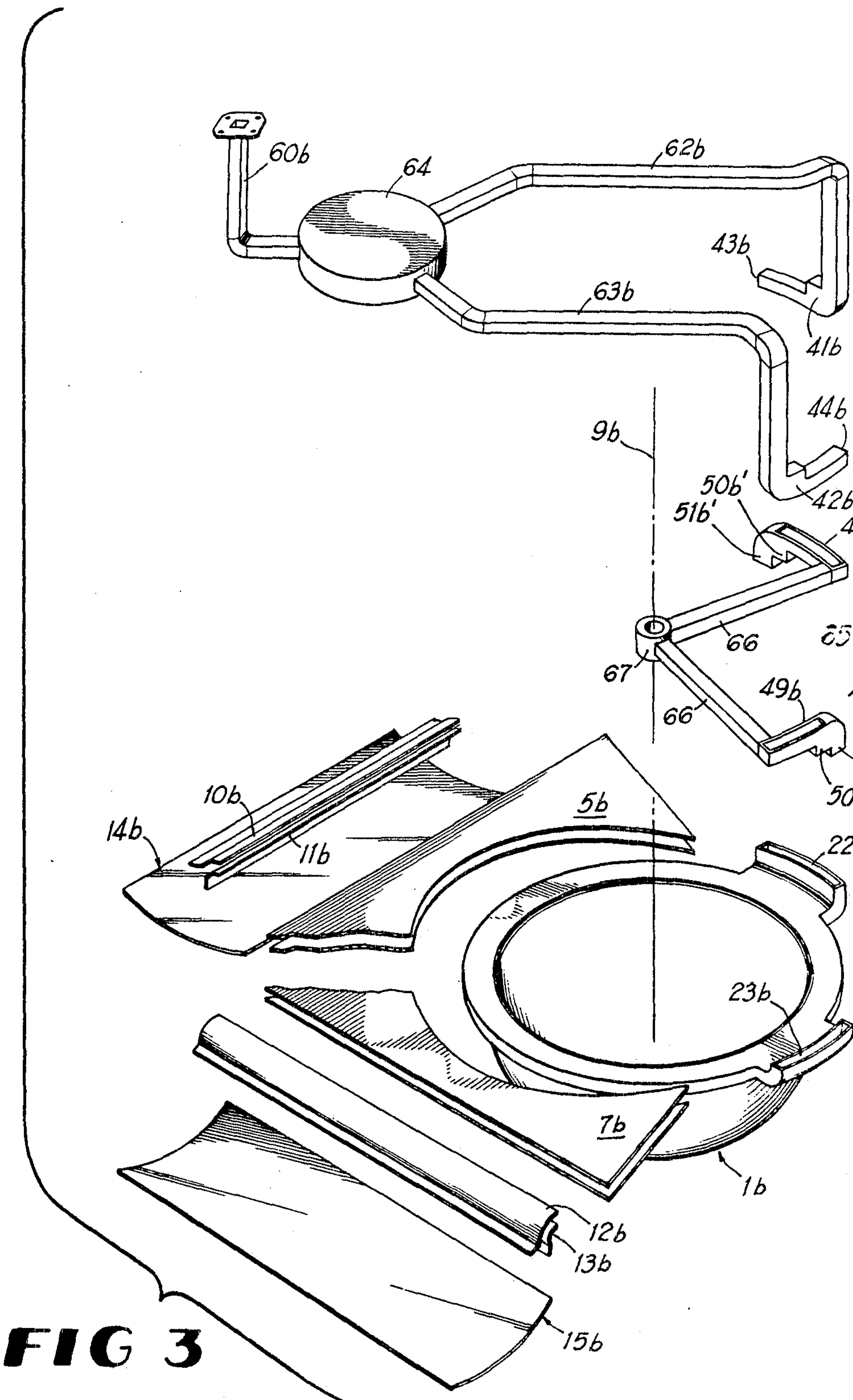
60b
64
62b
43b
41b
63b
44b
9b
42b
50b'
51b'
49b
66
65
67
49b
66
51b
50b
10b
14b
11b
5b
22b
23b
7b
1b
12b
13b
15b

FIG 3

FEED MECHANISM FOR A GEODESIC LENS

BACKGROUND OF THE INVENTION

Since a geodesic lens may be used in the transmission or reception of electromagnetic energy, it is customary to identify portions of a geodesic lens in terms of their function in the transmission of the electromagnetic energy while understanding that their functions may be reversed.

Goodman U.S. Pat. No. 3,343,171 discloses a modified helmet-type geodesic lens in which input lips are formed as partial cylinders whose axes are coincident with the major longitudinal axis of the lens and are joined to the outermost edges of the parallel plate conductors, which form the output lips of the lens, with semi-torroidal sections. This construction permits scanning the input lips along arcs centered on the longitudinal axis of the lens and displaced outwardly from the outermost edges of the output lips. In the transmission mode, focusing of collimated energy from a point source on these arcs is effected along an equi-phase line of collimated energy. The collimated energy is directed through the parallel plate conductors forming the output lips and then to a line source feed illuminating a parabolic cylinder reflector which transforms the rotating line of collimated energy to form a fan-shaped beam of collimated energy having an aperture dimension equal to the effective diameter of the lens in the scanning plane times the vertical aperture of the parabolic cylinder reflector in the non-scan plane. The fan-shaped beam in the far field of the antenna system can be moved, with exact one-to-one correspondence, by the arcuate movement of the feed horn. If the two input ports and also their associated reflectors are disposed 90° apart, movement of a feed horn along one feed arc will scan a fan beam from the first reflector which moves in a plane orthogonal to the scan plane of the second reflector. Thus, this system achieves, in one lens system, the full capability of two fan beam track-while-scan (TWS) operations which previously had required two separate lens systems such as disclosed in the Hollis U.S. Pat. No. 2,841,770.

The Hollis U.S. Pat. No. 3,018,450 discloses a rotor ring switch comprising a plurality of sectors each having an output terminating in a feed horn. Such a ring switch can be employed with the Goodman system (U.S. Pat. No. 3,343,171).

However, dead time between scans may present a serious problem.

BRIEF SUMMARY OF THE INVENTION

Accordingly, it is of primary concern in connection with this invention to provide a feed system for the Goodman type geodesic lens in which a plurality of input lips may be sequentially or simultaneously scanned with a rotor ring switch as above described, with a minimum of dead time between successive scans.

Basically, the above object is achieved by providing separate stationary coupling sectors overlying the respective input lips and positioned to feed the rotor ring switch such that no dead time is introduced by this arrangement, and by providing a further rotary coupling in the form of two semicircular sectors respectively coupled to the coupling sectors and in turn fed by a rotating semicircular sector. The number of feed horns is chosen to be large within the constraint that each feed horn element is at least equal in length to an input lip and the further rotary coupling is rotated at a speed much greater than the speed of rotation of the rotary ring switch, whereby the dead time introduced by the time required by the input junction of the rotating semicircular sector to transfer across the gaps between the two stationary semicircular sectors is minimized.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. **1** is an exploded perspective of one embodiment of the invention;

FIG. **2** is an exploded perspective of another embodiment of the invention; and

FIG. **3** is an exploded perspective of yet another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

In FIG. **1**, a geodesic lens **1** of the type disclosed in the Goodman U.S. Pat. No. 3,343,171 includes the main body **2** formed by two dished conductors with constant normal separation provided with annular parallel plates **3** and **4** which define output lips as disclosed in the Goodman patent. Parallel plate extensions **5**, **6** and **7**,**8** are joined to the respective plates **3** and **4** in planes coincidental therewith and perpendicular to the main longitudinal axis of the lens. The parallel plate extensions **5**,**6** and **7**,**8** are joined respectively to the reflector plates **10**,**11** and **12**,**13** which terminate in ports spaced from and illuminating the respective parabolic cylinder reflectors **14** and **15**. The axes of the parabolic reflectors **14** and **15** are orthogonal and lie in a common plane perpendicular to the axis **9**.

The two sets of input lips **16**,**17** and **18**,**19** are arcuate as shown and are of part-cylindrical form with the inner lips **17**, **19** and the outer lips **16** and **18** circumferentially spaced by 90° and joined to the respective annular plates **3** and **4** by semi-toroidal sections such as **20** and **21**, as described in the Goodman patent. Scanning along the arcuate lengths of the input ports **22** and **23** effects TWS capability as described in that patent.

Microwave energy is coupled to the main waveguide section **24** connected to a conventional transmitter/-receiver assembly, not shown, through the rotary coupling **25** having a radial arm section **26** terminating in the junction **27** leading to the rotary semicircular, longitudinally split section **28**. The sector **28** is approximately 180° in extent and is centered about the axis **9** and is driven in the direction of the arrow **29** at a predetermined speed synchronized with that of the ring switch **30**. Any suitable drive means may be employed and in FIG. **1**, the synchronous but differential speed drive is indicated at **31** in driving connection respectively with the elements **28** and **30** as illustrated by the symbolic drive connections **32** and **33**.

The two semicircular split waveguide sectors **34** and **35** are closely spaced with the rotating section **28** to couple therewith and each of the sectors **34** and **35** terminate in a junction **36** or **37** which connect through the waveguide sections **38**, **39** and **40** and through the junction **41** and **42** to arcuate, split waveguide segments **43** and **44** are positioned such that their ends **46** and **45** substantially register with the ends **55** and **54** of the respective ports **22** and **23**. The arcuate segments **43** and **44** therefore overlie the ports **22** and **23** and lie, of course, along a common circular path centered on the axis **9**.

The rotor **30** comprises a series of contiguous arcuate split waveguide segments **49** of equal lengths forming a full complement of such elements around a circle centered on the axis **9** about which the ring **30** is driven in the direction of the arrow **52**. Each segment **49** terminates at its trailing end in a junction **50** and a downwardly directed feed horn **51**. The assembly consisting of waveguide sections **28**, **34** and **35** therefore functions as a switch coupling the input waveguide **24** alternately with fixed segments **43** or **44** overlying the input lips of the lens. Concurrently, a horn **51** of a segment **49** of rotor **30** is scanning the length of the input lip to couple the microwave energy from the active fixed segment to the corresponding input lip.

The operation is such that the rotational speed of the rotor **30** is synchronized with that of the rotary sector **28** to assure that when the junction **27** has just traversed a gap **52** or **53** and thereby commences to activate a sector **34** or **35**, a feed horn **51** coupled to the respective stationary segment **43** or **44** thus activated is coincident with the leading edge **54** or **55** of an input port **22** or **23**. Obviously, then, the rotary segment **28** must be driven at a rotational speed which is N/2 times the speed of the rotor **30**, where N is the number of elements **49**. Thus, during the first 180° rotation of rotary section **28**, sector **35** (and therefore segment **44**) is activated and a horn **51** of a segment **49** of rotor **30** is traversing input lip **23** from end **54** to end **47**.

Since the arcuate lengths of segments **49** and input lips **22** and **23** may be proportioned such that a horn **51** may be positioned at the beginning of scan on the ready-to-be activated lens input lip when a horn **51** is at the end of scan on the other, or activated, input lip, there is no blanking time of the transmitter required for this function. Therefore, the blanking or dead time is only required during the time necessary for the junction of rotor segment **28** to traverse either gap **52** or **53** in the upper ring switch.

Because the rotational speed of the member **28** will thus be high, the resultant dead time will be low. Typically, the dead time can be made less than 1° at frequencies in the 35 GHz range. For example, in a practical embodiment, the ports **22** and **23** each subtend an angle of 18° which permits the rotor **30** to be divided into either sixteen or twenty segments **49** in order to allow a maximum of segments within the constraint that the arcuate length of each such segment must be at least equal to the length of the ports **22**, **23**. The speed of the sector **28** may thus be either eight or ten times the speed of the rotor **30**. However, it should be noted that if the arcuate length of 18° is chosen (twenty segments **49**), one may in fact use ten double-length segments **49** since only alternate 18° sectors of the rotor are actually activated. Then, the speed of the rotary sector **28** is N/2 times that of the rotor **30**, where N is a maximum number of segments **49** whose arcuate length is greater than but closely approaching the arcuate length of the input/output ports **22**, **23**, regardless of whether that number, or half thereof, is used.

In FIG. **2**, a modification is shown in which the rotary coupling **25** of FIG. **1** is obviated. The main waveguide section **60** in this case is offset from the axis **9**, rather than being centered thereon as is necessary in FIG. **1**. The section **60** is joined, at junction **61**, with the circular split waveguide ring **62**. The rotary semicircular segment ***28a*** is, in this case, joined through waveguide **63** with the rotating split waveguide ring **64** at junction **65**. The remainder of the assembly is as described in conjunction with FIG. **1**.

Therefore, junction **61** and split waveguide **62** is the stator and junction **65** and split waveguide **64** is the rotor of an input ring switch. Similarly, junction ***27a*** and split waveguide ***28a*** is the rotor and junctions ***37a***, ***36a*** and split waveguides ***34a***, ***35a*** are the stators of a commutating ring switch. Arcuate split waveguide segments ***43a***, ***44a***, and junctions ***42a***, ***43a*** are the stator, and split waveguide segments ***49a*** and junctions ***50a*** are the rotor of the scanning ring switch.

In FIG. **3**, a modification is shown in which the rotary coupling of FIG. **1** or the input ring switch of FIG. **2** is replaced by another type of waveguide switch. The main waveguide ***60b*** feeds microwave energy into either a standard rotary waveguide switch of a Ferrite Switch **64**. The output of the switch **64** is alternately fed to waveguides ***62b*** or ***63b*** and thence to arcuate segments ***43b*** or ***42b*** and associated junctions ***41b*** and ***42b***, respectively. These arcuate segments overlie lens lips ***22b*** and ***23b*** in similar fashion to FIG. **1** and FIG. **2**. Interposed between the arcuate segments ***43b***, ***42b*** and lens lips ***22b***, ***23b*** are two segmental waveguide sections ***49b***, mechanically spaced from hub **67** by means of spokes **66**. These segments ***49b*** perform the same function as segments **49** in FIG. **1**, i.e. they receive microwave energy from the overlying waveguide segments ***43b*** and ***44b*** and alternately transmit this energy into the lens input lips ***22b*** and ***23b*** by means of their horns ***51b'*** and ***51b***. In this instance, however, the assembly of the two arcuate segments ***49b*** and ***50b*** is caused to oscillate about axis ***9b*** of the lens as shown by arrow **65** rather than rotate as was the case with the segmented ring **30** of FIG. **1**. This construction as shown in FIG. **3** allows the use of much shorter path lengths from the input waveguide ***60b*** to the lens input lips ***22b***, ***23b*** and also minimizes the number of arcuate segments ***49b***, junctions ***50b*** and horns ***51b***.

What is claimed is:

1. In combination with a geodesic Luneberg lens having a longitudinal axis, annular parallel plate conductors centered on said axis and lying in planes perpendicular thereto, said conductors defining output lips of said lens, a first set of inner and outer plates joined respectively to said parallel plate conductors and lying on spaced arcs centered on said axis and disposed outwardly of said parallel plate conductors, said first set defining a first set of input lips, and a second set of inner and outer plates joined respectively to said parallel plate conductors and lying on spaced arcs centered on said axis and disposed outwardly of said parallel plate conductors, said second set defining a second set of input lips circumferentially displaced from said first set of input lips; microwave feed means for scanning said sets of input lips along their arcuate lengths, said feed means comprising a pair of stationary, arcuate waveguide segments positioned above said input lips, a common waveguide feed section, commutating feed means for alternately coupling said segments to said common waveguide section, a rotatable ring of feed horns disposed between said waveguide segments and said input lips, said ring being centered on said longitudinal axis.

2. In the combination as defined in claim **1** wherein said rotatable ring of feed horns oscillates through an arc equal to the arcuate length of said input lips.

3. In the combination as defined in claim **2** wherein the commutating feed means is a Ferrite Switch.

4. In the combination as defined in claim 2 wherein the commutating feed means is a rotary waveguide switch.

5. In the combination as defined in claim 1 wherein said commutating feed means is rotated in synchronization with said rotatable ring but faster than said ring.

6. In the combination as defined in claim 5 including means for driving said rotatable feed means and said ring at such relative speeds such that the speed of said feed means is N/2 times the speed of said ring, where N is a number of feed horns which can be accommodated in said ring, each such feed horn having an arcuate length at least equal to and nearly the same as the arcuate lengths of said input lips.

7. In the combination as defined in claim 6 wherein each feed horn includes a second arcuate segment facing said waveguide segments and an oppositely facing feed horn outlet at one end thereof.

8. In the combination as defined in claim 7 wherein said second arcuate segments provide a full complement in said ring.

9. In the combination as defined in claim 5 including two semicircular waveguide sections coupled respectively to said arcuate waveguide segments, and a rotatable semicircular waveguide segment overlying said two semicircular segments.

10. In the combination as defined in claim 9 wherein said common waveguide sections extends along said axis and said rotatable semicircular waveguide section is directly coupled thereto.

11. In the combination as defined in claim 9 wherein said common waveguide section is parallel to but offset from said axis, and including a substantially circular waveguide section coupled directly to said common waveguide section, and a second substantially circular waveguide section directly coupled to said rotatable semicircular section.

12. In the combination as defined in claim 10 including means for driving said rotatable feed means and said ring at such relative speeds that the speed of said feed means is N/2 times the speed of said ring, where N is a number of feed horns which can be accommodated in said ring, each such feed horn having an arcuate length at least equal to and nearly the same as the arcuate lengths of said input/output lips.

13. In the combination as defined in claim 12 wherein each feed horn includes a second arcuate segment facing said waveguide segments and an oppositely facing feed horn outlet at one end thereof.

14. In the combination as defined in claim 13 wherein said second arcuate segments provide a full complement in said ring.

15. In the combination as defined in claim 9 including means for driving said rotatable feed means and said ring at such relative speeds that the speed of said feed means is N/2 times the speed of said ring, where N is a number of feed horns which can be accommodated in said ring, each such feed horn having an arcuate length at least equal to and nearly the same as the arcuate lengths of said input/output lips.

16. In the combination as defined in claim 15 wherein each feed horn includes a second arcuate segment facing said waveguide segments and an oppositely facing feed horn outlet at one end thereof.

17. In the combination as defined in claim 16 wherein said second arcuate segments provide a full complement in said ring.

18. In a microwave feed for a geodesic lens having two arcuate input ports, the combination of first rotatable means for sequentially scanning said input ports along the arcuate lengths thereof and including a full complement ring of feed horns whereby an input port is scanned during a small angular movement of said ring, and further rotatable means for alternately coupling two different horns to a common waveguide section during each revolution of said further rotatable means, and drive means for driving said further rotatable means in synchronization with but much faster than said ring whereby to minimize dead time due to switching of said further rotatable means.

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